# ELK HABITAT SELECTION ON THE CLEARWATER NATIONAL FOREST, IDAHO

JAMES W. UNSWORTH,[1,2] Idaho Department of Fish and Game, Route 2 Box 12, Kamiah, ID 83536, USA
LONN KUCK,[3] Idaho Department of Fish and Game, 1540 Warner, Lewiston, ID 83501, USA
EDWARD O. GARTON, Department of Fish and Wildlife, University of Idaho, Moscow, ID 83843, USA
BART R. BUTTERFIELD,[3] Department of Fish and Wildlife, University of Idaho, Moscow, ID 83843, USA

***Abstract:*** Habitat management for bull and cow elk (*Cervus elaphus nelsoni*) may require different forest management standards because of likely sexual differences in distribution and habitat selection patterns. Current standards are based on the habitat use patterns of cow elk. Thus, we located 121 radiocollared elk (101 bulls, 20 cows) 4,527 times in the forested habitats of northcentral Idaho during 1986–90 to determine patterns of habitat selection. During winter, habitat selection patterns of ≥2-year-old and yearling bull elk were similar, but cow elk used more shrub habitats and less-open timber types. Cows typically used moderately steep areas on south-facing to west-facing aspects on the middle to lower elevational portions of the winter range. Bulls were more often found using small benches or ridgetop areas near the upper portion of hillsides. From spring through fall, elk shifted from using a high proportion of shrub and open timber habitats to use of timber habitats. In general, elk in areas with roads used habitats with greater canopy cover. This pattern was most pronounced for cow and ≥2-year-old bull elk. Yearling bulls tended to select habitats in proportion to availability, whereas cow and ≥2-year-old bull elk showed preference for open timber habitats during fall in nonroaded habitats and for timber habitat in areas with roads during summer and fall. Bulls tended to use higher proportions of lower slopes and stream bottoms than did cows during summer, and somewhat steeper areas during fall. Concern over forage production on summer range should be secondary to reducing disturbance and providing secure habitat during fall hunting seasons.

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***Key words:*** *Cervus elaphus nelsoni*, elk, habitat effectiveness, habitat use, Idaho, roads.

Elk habitat use patterns have been evaluated throughout the Intermountain West (Knight 1970, Mackie 1970, Skolvin 1982, Irwin and Peek 1983, McCorqendale et al. 1986; Edge et al. 1987, 1988). Such studies are commonly conducted to determine the effects of habitat change. Considerable research has been conducted to provide guidelines that coordinate silvicultural practices and elk habitat needs (Black et al. 1976, Leege 1984, Lyon et al. 1985) because a large portion of the elk range in North America has been affected by logging and road building. Increased access via road building has been associated with decreased use of summer habitats (Lyon et al. 1985) and increased hunter mortality of bull elk (Unsworth et al. 1993). The majority of these studies, however, have only considered habitat use patterns of cow elk. Because differences likely exist in the distribution, habitat use patterns, and home range sizes of bull and cow elk (Peek and Lovaas 1968, Leege and Hickey 1977, Franklin and Lieb 1979, Marcum and Edge 1991), habitat management for bulls may require different forest management practices and standards than currently exist. Thus, we wanted to determine (1) if there were differences in the seasonal habitat use patterns of cow and bull elk, (2) if habitat use patterns differed between areas with roads (roaded) and areas without roads (nonroaded), and (3) if currently used summer habitat guidelines were appropriate for bull elk.

## STUDY AREA

The study area was north of the Clearwater and Lochsa rivers in northcentral Idaho. The area was approximately 3,100 km$^2$ in size and located primarily within the Clearwater National Forest (Fig. 1). Physiography was characterized by small, steep-sided drainages. Elevations ranged from 425 m at Syringa, Idaho, to 2,030 m on Castle Butte.

Annual precipitation recorded at Fenn Ranger Station near the mouth of the Lochsa River

[1] Present address: Idaho Department of Fish and Game, 3101 South Powerline Road, Nampa, ID 83686, USA.
[2] E-mail: junswort@idfg.state.id.us
[3] Present address: Idaho Department of Fish and Game, P.O. Box 25, Boise, ID 83707, USA.

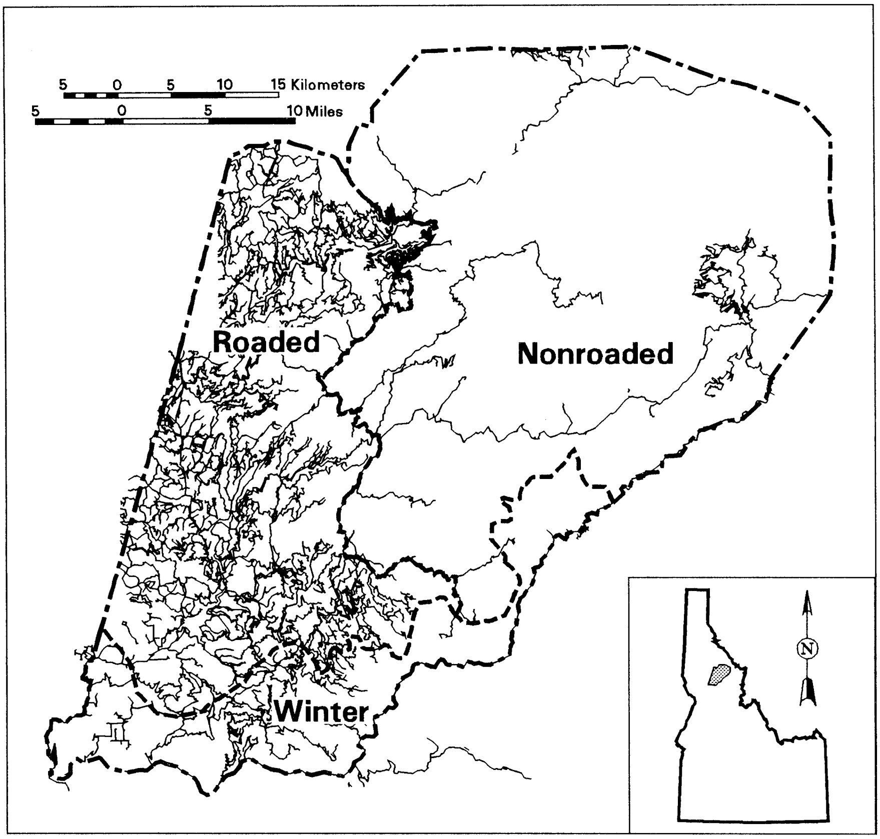


Fig. 1. Map of the study area in northcentral Idaho showing forest roads. The western portion of the study area was heavily roaded (1.94 km/km$^2$), whereas the eastern portion had very low road densities (0.29 km/km$^2$) and no logging activities. The study area outline represents the combined range of radiocollared elk during the study, 1986–90.

averaged 90 cm, 51% of which fell from November through March. Temperatures at Fenn Ranger Station ranged from a January average of −1.6°C to a July average of 21.3°C, with a mean annual temperature of 9.7°C (Abramovich et al. 1998).

Vegetation ranged from dry ponderosa pine (*Pinus ponderosa*)–Douglas-fir (*Pseudotsuga menziesii*) forests at lower elevations to Engelmann spruce (*Picea engelmannii*)–subalpine fir (*Abies lasiocarpa*) forests at upper elevations. Fire and timber harvest exerted a major role in shaping landscape patterns; about 25% of the area was seral shrub habitats or clearcuts with grass–forb understories. Another 25% was mixed open timber–shrubs, and 50% consisted of closed-canopy forest (>60% crown closure). The western (roaded) portion of the study area was heavily roaded (1.94 km/km$^2$) and had active logging operations. The eastern (nonroaded) portion had very low road densities (0.29 km/km$^2$) and no logging activities.

Land uses included commercial timber harvest, limited livestock grazing, fishing, camping, and hunting. There was a 28-day either-sex archery season during September and a 26-day rifle season for any antlered elk during October. Elk density during summer was roughly 1/km$^2$, and postseason bull:cow ratios ranged from 14:100 on the western portion of the study area to 35:100 on the eastern portion (Idaho Department of Fish and Game 1998). The lower bull:cow ratio on the western portion of the study area was associated with high road and hunter densities (Unsworth et al. 1993).

## METHODS

Elk were darted from a helicopter, ear-tagged, and radiocollared. Elk were captured annually in forest openings during winter and spring throughout the study area. Elk were classified as cow, yearling bull, or ≥2-year-old bull elk. Age was estimated from tooth replacement and wear (Quimby and Gaab 1957). We followed an Idaho Department of Fish and Game animal welfare protocol (Policy FW-21.00) while conducting our research.

We located each radiocollared elk during daylight from a Cessna 185 airplane at 1–4-week intervals during the nonhunting season and 2–3 times/week during the hunting season. We recorded the latitude and longitude (from the aircraft's LORAN-C navigation system) of each radiocollared elk. Overall radiotracking error via the LORAN-C navigation system was 473 ± 131 m (Unsworth et al. 1993), and these coordinates were used only for home range analysis (Unsworth 1993). Radiotracking error was determined by comparing navigation system coordinates with coordinates measured from 7.5-min topographic maps. We used mapped coordinates from fixed points and hidden radiocollars. Habitat characteristics were determined visually from the airplane. Radiocollared elk were occasionally located together, wherein each animal was assigned the same habitat characteristics.

We used Manly's selectivity index (Manly et al. 1972, Manly 1974; Chesson 1978, 1983) and log-linear modeling (Heisey 1985) to analyze habitat selectivity. The subscript $I$ ($I = 1, \ldots I$) indicates the habitat type (shrub–clearcut, open timber, timber). Classifying factors (season, sex, area) were indicated as $j$, $k$, and $l$ with $J$, $K$, and $L$ categories, respectively. The availability of habitat type $I$ to an elk in class $jkl$ is indicated by $A_{ijkl}$. The probability that the next habitat ($I$) used by elk $jkl$ is

$$P_{ijkl} = \frac{\alpha_{ijkl} A_{ijkl}}{\sum_{h=1}^{I} \alpha_{hjkl} A_{hjkl}}.$$

The $\alpha_{ijkl}$ term is Manly's selectivity index and acts as a weighting factor for habitat use that is not random. If habitat use is nonselective, then the $\alpha_{ijkl}$s are equal and $P_{ijkl}$ is the same as the habitat availability (Heisey 1985). We calculated the $\alpha_{ijkl}$s and their standard errors with GLIM 3.77 (Swan and Baker 1989). We calculated 95% confidence intervals (Manly 1974) and adjusted them with the Bonferroni method (Miller 1981) to make comparisons among selectivity indices. Elk habitat use was cross-classified by sex and age, season (spring: Apr–Jun; summer: Jul–Sep; fall: Oct–Nov; winter: Dec–Mar) and area (roaded, nonroaded, winter range). Winter locations were treated separately because roads on the study area were closed during winter. The dependence of habitat selectivity on sex, age, season, and area was determined with conditional tests (Fienberg 1970, Bishop et al. 1975).

We classified habitat use for individual elk during radiotelemetry flights, but we assumed individual elk selectivities were identical and pooled them for analysis (Heisey 1985). This analysis assumes resource usages are independent and that resource availability does not change during the duration of the study (Heisey 1985). Habitat availabilities were measured separately for the roaded, nonroaded, and winter range portions of the study area with a Geographic Information System (GIS), GRASS (Westervelt 1988; Fig. 1). The study area boundary represented the cumulative area used by radiocollared elk. The GIS database consisted of classified and ground-truthed LANDSAT MSS imagery and a digital road map (1:24,000 scale).

Monthly differences in habitat use among cow, yearling bull, and ≥2-year-old elk were tested with chi-square statistics. Because sample size varied among months, we used the phi coefficient to describe relative differences among months and between classes of elk (Zar 1984, Wilkinson 1990).

We also visually estimated slope and topography (ridgetop, upper slope, midslope, lower slope, bench or flat, stream bottom) for individual elk during radiotelemetry flights. Aspect was determined by referring to the aircraft compass. Seasonal differences in the use of these features among cow, yearling bull, and ≥2-year-old bull elk were tested with chi-square statistics (Zar 1984).

## RESULTS

We located 121 radiocollared elk (101 bulls, 20 cows) 4,527 times from 1986–90 ($\bar{x} = 37.41$, SE = 3.08; locations from individual elk were ≤2.7% of the total). Sixty-eight of the bull elk were collared as yearlings. Yearling bulls were located 704 times, ≥2-year-old bulls were located 2,810 times, and cows were relocated 1,013 times. Individual elk were located from 1 to 120 times during the study.

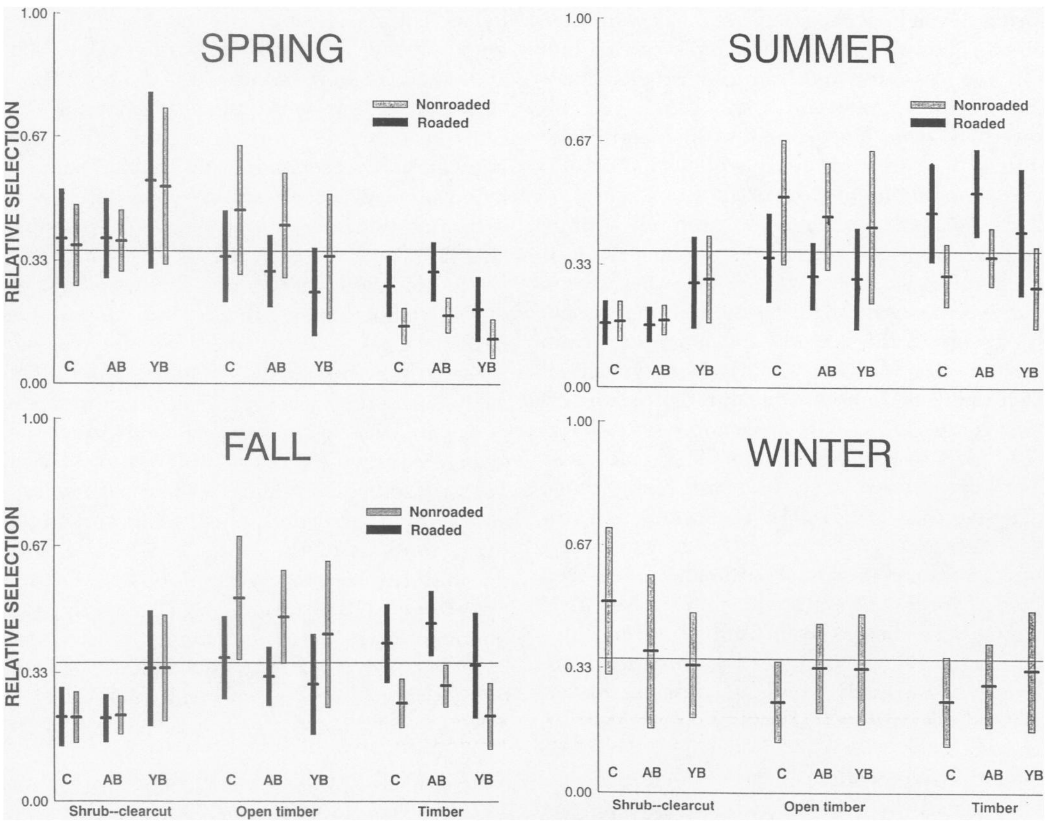


Fig. 2. Habitat selectivities and their 98% confidence intervals for elk on the Lochsa study area, Idaho, 1986–90. A selectivity of 0.33 indicates habitat is selected in proportion to availability. C = cow, AB = ≥2-year-old bull, and YB = yearling bull.

## Habitat Use

We fit 2 log-linear models to evaluate habitat use and estimate habitat selectivities: a winter model (Model I) and a spring, summer, and fall model (Model II). In Model I, we evaluated winter habitat use among yearling bulls, ≥2-year-old bulls, and cow elk. During winter, habitat-specific selectivities ($I$) were significant ($G^2{}_2 = 112.83$, $P < 0.001$) and were dependent on type ($k$) of elk ($G^2{}_4 = 18.08$, $P = 0.005$). We were unable to fit a reduced log-linear model to this dataset, and selectivity parameters were estimated from the full model ($\alpha_{ik}$; Fig. 2). On the log scale, Model I can be written following Heisey (1985) as

$$\ln e_{ik} = \ln \alpha_{ik} + \ln A_{ik} + d_k,$$

where $e_{ik} = P_{ik}N_k$, and $N_k$ = total number of all observations of habitat use by elk type $k$. The $d_k$ term is similar to a block effect in analysis of variance (Heisey 1985).

During winter, selection patterns of ≥2-year-old and yearling bull elk were similar, but cow elk used more shrub habitats and less open timber types. Differences in habitat use between cow and bull elk were greatest during December–February (Fig. 3). In March, cow elk increased use of timbered types, and use patterns became similar to bulls.

Along with the selection of different cover types during winter, cow, yearling bull, and ≥2-year-old bull elk used different aspects ($\chi^2{}_{14} = 38.28$, $P < 0.001$), topography ($\chi^2{}_{10} = 37.40$, $P < 0.001$), and steepness of slope ($\chi^2{}_4 = 10.42$, $P = 0.034$). Cows typically used moderately steep areas on south-facing to west-facing aspects on the middle to lower hillsides of the winter range. Bulls were more often found using small benches or ridgetop areas near the upper portion of hillsides. Yearling bull elk were often associated with cow groups but used more westerly aspects (Table 1).

In Model II, we evaluated seasonal habitat use in roaded and nonroaded habitats. Habitat-

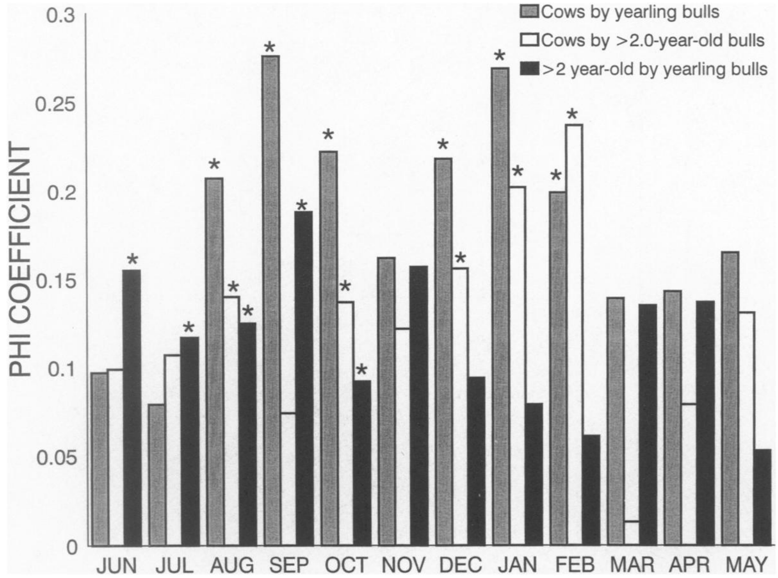


Fig. 3. Relative differences in monthly habitat use between cow and yearling bull, cow and ≥2-year-old bull, and yearling and ≥2-year-old bull elk on the Lochsa study area, Idaho, 1986–90. An asterisk indicates the phi coefficient was significantly different from zero ($P < 0.10$).

specific selectivities ($I$) differed ($G^2_2 = 65.67$, $P < 0.001$) and were dependent on type ($k$) of elk ($G^2_4 = 56.80$, 4 df, $P < 0.001$), season ($j$; $G^2_4 = 203.66$, $P < 0.001$), and road access ($l$; $G^2_2 = 102.40$, $P < 0.001$; Fig. 2). On the log scale, Model II can be written as

$$\ln e_{ijkl} = \ln \alpha_{ij} + \ln \alpha_{ik} + \ln \alpha_{il} + \ln A_{ijkl} + d_{jkl}.$$

Elk in summer and fall shifted from a spring pattern of using a high proportion of shrub–clearcut and open timber habitats to timber habitats. In general, elk in roaded areas used habitats with greater canopy cover. Use of timber habitats was most pronounced for cow and ≥2-year-old bull elk. Yearling bulls tended to select habitats in proportion to availability, whereas cow and ≥2-year-old bull elk showed preferences for open timber habitats during fall in nonroaded habitats, and for timber habitat in roaded areas during summer and fall (Fig. 2). Differences in habitat use between cows and both classes of bulls were at a maximum from August to February. The exception was cows and ≥2-year-old bulls during September and all classes of elk during November (Fig. 3).

When using spring, summer, and fall ranges, cows and bulls did not segregate themselves spatially to the extent we observed during winter. Cow elk used more southern aspects during spring than both classes of bull elk ($\chi^2_{14} = 28.59$, $P = 0.012$). In comparison to cows, bulls tended to use higher proportions of lower slopes and stream bottoms during summer ($\chi^2_{10} = 22.35$, $P = 0.013$), and somewhat steeper areas during fall ($\chi^2_4 = 21.12$, $P < 0.001$; Table 1).

## DISCUSSION

Seral shrub habitats are important to elk in northern Idaho during winter because forage is abundant and shrub habitats have persisted on southern exposures where less snow accumulates (Leege and Hickey 1977, Hershey and Leege 1982, Irwin and Peek 1983). However, we found that older bulls used shrub habitats less and open timbered types more than cows during winter. On the Lochsa, there was considerable mixing of bulls and cows on winter range, but older bulls tended to segregate themselves on portions of the winter range dominated by open timber stands. In areas where this habitat was limited, bulls selected bench areas on the middle to upper portions of winter range. Older bulls were also observed wintering in deep snow areas alone or in small groups (2–3 bulls) at higher elevations. These bulls were sometimes several kilometers from the larger concentrations of elk on more "traditional" winter range. Watson and Staines (1978) reported that female red deer (*Cervus*

Table 1. Seasonal use (%) of aspect, topography, and slope by cow, yearling bull, and ≥2.0-year-old bull elk in northcentral Idaho, 1986–90.

| Site characteristics | Cows | | | | Yearling bulls | | | | ≥2.0-year-old bulls | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter | Spring | Summer | Fall | Winter | Spring | Summer | Fall | Winter | Spring | Summer | Fall |
| Aspect | $n$ = 216 | $n$ = 194 | $n$ = 298 | $n$ = 241 | $n$ = 94 | $n$ = 196 | $n$ = 200 | $n$ = 106 | $n$ = 437 | $n$ = 556 | $n$ = 1008 | $n$ = 614 |
| North | 2.3 | 7.2 | 14.4 | 14.9 | 1.1 | 6.6 | 8.5 | 9.4 | 7.8 | 11.2 | 18.5 | 21.2 |
| Northwest | 2.8 | 5.2 | 4.4 | 7.1 | 2.1 | 5.6 | 6.5 | 9.4 | 2.8 | 6.5 | 6.7 | 6.8 |
| Northeast | 1.4 | 2.6 | 8.1 | 7.9 | 0.0 | 0.5 | 8.5 | 12.3 | 2.8 | 4.9 | 6.9 | 7.8 |
| East | 0.0 | 11.9 | 19.1 | 16.6 | 0.0 | 12.2 | 15.5 | 10.4 | 0.2 | 14.6 | 14.9 | 14.7 |
| Southeast | 4.6 | 9.8 | 12.4 | 11.6 | 6.4 | 8.2 | 17.0 | 16.0 | 6.0 | 9.5 | 12.2 | 10.3 |
| South | 50.9 | 34.0 | 17.8 | 19.1 | 35.1 | 27.0 | 21.5 | 23.6 | 39.6 | 26.1 | 18.6 | 17.9 |
| Southwest | 16.2 | 12.9 | 9.7 | 9.1 | 20.2 | 13.8 | 10.0 | 10.4 | 14.9 | 12.4 | 8.9 | 9.3 |
| West | 15.3 | 16.5 | 14.1 | 13.7 | 29.8 | 26.0 | 12.5 | 8.5 | 15.3 | 14.9 | 13.2 | 12.1 |
| Topography | $n$ = 254 | $n$ = 205 | $n$ = 302 | $n$ = 252 | $n$ = 174 | $n$ = 214 | $n$ = 209 | $n$ = 107 | $n$ = 545 | $n$ = 585 | $n$ = 1027 | $n$ = 643 |
| Ridgetop | 13.4 | 8.8 | 8.9 | 5.2 | 17.8 | 10.3 | 10.5 | 5.6 | 15.8 | 10.1 | 8.8 | 8.1 |
| Upper slope | 16.9 | 31.2 | 31.5 | 23.0 | 26.4 | 24.8 | 35.4 | 29.0 | 25.1 | 27.0 | 28.2 | 24.7 |
| Midslope | 40.6 | 39.0 | 42.1 | 35.3 | 40.8 | 37.9 | 31.6 | 40.2 | 39.3 | 38.8 | 35.4 | 37.2 |
| Lower slope | 27.2 | 14.2 | 9.3 | 22.2 | 9.2 | 14.5 | 13.4 | 16.8 | 14.7 | 13.5 | 15.7 | 18.5 |
| Bench–flat | 1.6 | 5.9 | 3.6 | 10.7 | 5.8 | 11.7 | 6.7 | 4.7 | 4.6 | 8.2 | 5.8 | 8.9 |
| Stream bottom | 0.4 | 1.0 | 4.6 | 3.6 | 0.0 | 0.9 | 2.4 | 3.7 | 0.6 | 2.4 | 6.0 | 2.6 |
| Slope | $n$ = 211 | $n$ = 201 | $n$ = 298 | $n$ = 252 | $n$ = 80 | $n$ = 204 | $n$ = 209 | $n$ = 107 | $n$ = 426 | $n$ = 571 | $n$ = 1022 | $n$ = 643 |
| <20% | 20.4 | 47.8 | 51.7 | 54.4 | 16.3 | 43.6 | 41.2 | 43.0 | 26.5 | 49.6 | 44.0 | 37.6 |
| 20–40% | 73.9 | 50.8 | 46.0 | 43.7 | 76.3 | 54.4 | 54.6 | 53.3 | 63.6 | 48.0 | 52.4 | 59.1 |
| >40% | 5.7 | 1.5 | 2.4 | 2.0 | 7.5 | 2.0 | 4.3 | 3.7 | 9.9 | 2.5 | 3.6 | 3.3 |

*elaphus*) wintered on higher-quality forage than males, and Clutton-Brock et al. (1982) found male red deer spent more time feeding in shelter than did females. Elevational segregation of sexes in elk was also documented by Peek and Lovaas (1968) and Leege and Hickey (1977).

During spring, elk of both sexes responded to greening vegetation and continued to use cover types with open canopies. Other studies have documented selection of habitats in spring that produce large quantities of succulent early-growing vegetation (Hershey and Leege 1982, Irwin and Peek 1983). Compared to winter, our elk in nonroaded habitats increased use of open timber types; in roaded habitats, they increased use of closed-canopy timbered types. Recreation and logging activity associated with roads increased during spring and may have contributed to the higher use of timbered types we observed in roaded areas (Lyon et al. 1985). Cow elk may also have increased use of timbered types during calving. Kuck et al. (1985) found calves subjected to simulated disturbance increased use of areas with greater canopy coverage than did undisturbed calves. Considerable predation on elk calves by large carnivores occurs in the Lochsa area (Schlegel 1976; M. W. Gratson, Idaho Department of Fish and Game, personal communication); hence, this predation likely also influences spring habitat selection.

Use of timbered cover types continued to increase during summer for both sexes, but the use of timber was most pronounced in roaded habitats. Disturbance plays a role in the increased use of timbered habitats during summer because elk avoid areas near forest roads (Lyon 1979, 1983). Both sexes increased use of cover on the Lochsa during summer, but older bulls showed the strongest preference for timbered types. The increased use of cover in roaded habitats probably was more influenced by disturbance than in the nonroaded habitats. Marcum (1975) determined bulls moved significantly farther than cows from open road systems, clearcuts, and disturbances that may have been associated with roads. In both Marcum's study and ours, increased use of cover was likely also associated with delayed plant phenology. The general trend in elk habitat use during summer is a shift from lower to higher elevations, sunny to cool sites, south to north aspects, and well-drained to wet sites (Nelson and Leege 1982).

Differential use of habitats by sex of elk has not been consistently observed. Pederson et al. (1980) indicated no consistent differences in habitat selection among yearling male, yearling female, and adult female elk. Franklin and Lieb (1979) reported bull and cow groups segregated themselves, and this segregation increased with age of bulls. Clutton-Brock et al. (1982) reported mature red deer males selected breeding territories with more nutritious green forage than did immature males. Geist (1982) hypothesized that females should compromise forage quality and quantity in favor of security, and males should compromise security in favor of better forage. He also speculated that yearling males should show the greatest differences in habitat use patterns from females and older males during the time when a female is giving birth to another calf, and during the breeding season.

On the Lochsa, yearling and older bulls used different habitats through summer and fall. By early winter, however, when young bulls were about 18 months old, their habitat use patterns became similar to older bulls. Differences in habitat use between yearling bulls and both cows and older bulls were at a maximum during the rut in September, when older bulls may have excluded young bulls from breeding habitats. In elk populations where few older bulls are present, habitat use patterns of yearling bulls and cow elk would be expected to be more similar, particularly in the fall (Noyes et al. 1996).

Both bull and cow elk on the Lochsa study area showed a strong preference for the closed timber habitat type during fall. This use is probably related to the increased human activity associated with the fall hunting season (Unsworth and Kuck 1991) and the continued availability of succulent and nourishing forage. As timber is harvested, areas that provide security habitat become more restricted in size and scattered in distribution.

## MANAGEMENT IMPLICATIONS

Timber management and road building have a great effect on elk habitat in the Northwest. Considerable work has been conducted on summer habitat use patterns of elk, and this information has been incorporated into habitat management guidelines for elk (Black et al. 1976, Leege 1984, Lyon et al. 1985). These guidelines generally predict potential habitat use of an area from the amount of various cover and forage combinations, along with road densities. In north Idaho, premier summer elk habitat would consist of a roadless area with no cattle use, at least 40% cover, and adequate forage areas that are <300 m wide (Leege 1984). On both the roaded and nonroaded portions of our study area, the availability of timber habitat that would meet these cover requirements was about 50%. This habitat type was used in proportion to availability in nonroaded areas, but a preference for this type was shown in roaded habitats. We recommend that at least 50% of roaded habitats be maintained in vegetation that meets the requirements of cover. Leege (1984) recommended using average home range size (15.4 km$^2$) as the minimum size for analysis units when evaluating summer habitat. Using different methods to calculate home range size, Unsworth (1993) indicated a larger evaluation area may be appropriate when bull elk are considered. We recommend a 70–85 km$^2$ evaluation area.

Maintenance of early to mid-seral stage habitat will provide long-term benefits for elk on winter ranges by providing more forage (Leege and Hickey 1971, Irwin and Peek 1983), but reductions in cover and the increased access associated with timber harvest on summer and fall ranges will likely be more detrimental to elk in terms of reducing security than beneficial in terms of forage production (Unsworth et al. 1993). The summer elk habitat guidelines used in north Idaho (Leege 1984) probably meet most of the biological needs of both bull and cow elk during summer; however, we recommend a larger portion of managed areas maintained in cover and more restrictive access management than is currently practiced on most national forests.

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